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CLASS II. AVES.—BIRDS.*

TEGUMENTARY SYSTEM.

As the body of the Mammalia is very generally covered with hair so that of Birds is clothed with feathers, which belong, like it to the epidermic structures. The skin of the Mammalia is much stronger than that of Birds, for although the larger Wading, Aquatic Birds and the Ostriches, have a thick hide, yet the corium is in general throughout the class thin, transparent, and very highly vascular, from the large follicles of the feathers which penetrate into the subcutaneous cellular tissue being supplied by numerous vessels. The epidermis is exceedingly delicate upon those parts of the body where feathers are met with, but dry and constantly desquamating. In featherless parts, as upon the head and neck of many Birds, it becomes very much thickened, and forms callosities, wattles, and combs, in which, in addition to the cellular, what are called the erectile and elastic tissues are often developed, while at the same time red and blue pigmentary cells occur beneath the epithelium. Beneath the integument are found, as in Man, the subcutaneous mucous crypts, which are particularly conspicuous, as in Aquatic birds, upon the joints of the posterior extremities. Upon the toes and feet there occur plates and scales of horny tissue, and both the toes and beak are invested by laminiform horny sheaths, which may be completely detached from the bony

* Class AVES.

Order I. Accipitrinæ s. Rapaces { Diurnæ.—Ex. *Eagle, Falcon, Vulture.* Nocturnæ.—Ex. *Owls.*

II. Passerinæ. { Ex. All true *singing Birds* and those which, having no song, yet possess a complicated inferior larynx, as the *Sparrow, Rook, Shrike, &c.*

III. Scansores. { Ex. *Woodpecker, Cuckoo, Parrot, Toucan,* with those genera which, though related by external characters to the singing Birds, are devoid of a muscular vocal apparatus, viz., *Alcedo, Upupa, Merops, Cypselus, Trochilus, &c.,* and constitute the subdivision Picariæ.

IV. Gallinæ.—Ex. *Pheasant, Turkey, Partridge, Pigeon.*

V. Brevipennes or Struthionidæ. { Ex. *Ostrich, Cassawary, Emeu, Apteryx.*

VI. Grallæ.—Ex. *Bustard, Heron, Snipe, Flamingo.*

VII. Palmipedes.—Ex. *Divers, Albatross, Pelican, Goose.*

structures beneath. Occasionally the feathers assume a hair-like character, as upon the eyelids and base of the bill, *e. g.* in the Raven. It is very rarely that true hairs resembling bristles are met with, as upon the neck of the Turkey.

The epidermic plant-like horny structures of Birds, the Feathers, are divided into Down-feathers and Contour or Quill-feathers. The first are delicately soft and flexible, mostly of a gray or grayish-yellow color, and lie beneath obscured by the quill-feathers. There are feathers which are entirely downy, but each quill-feather, even the large primaries of the wing, has some strips of down at its commencement. The feathers of the neck and trunk form in most Birds circumscribed patches (*pterylæ*), which are distinctly defined by means either of intervals naked or beset with down.

In a perfectly formed Feather, the following parts may be distinguished. 1st. The stem (*scapus*), which forms the principal part of the feather; it is cylindrical or fusiform, and is prolonged inferiorly into the transparent hollow part, the quill (*calamus*), by which it is attached to the skin. Within the quill is found what is called the pith, which consists of membranous cones arranged one upon the other. Externally, where the vane or beard of the feather commences, the stem becomes medullary, and is then called the Shaft (*rachis*). This shaft, over the back of which the quill is continued as a horny investment, is almost always quadrangular, and rarely quite flat, as in Aptenodytes. The inferior surface of the shaft, namely, that which is turned toward the body of the bird, is hollowed out into a groove, and is depressed at the commencement of the quill into an umbilical fossa, near or from which the accessory plume (*hyporhachis*) arises. This resembles the main shaft, in giving off a bilinear series of barbs, and the two together form an apparently double feather. It is wanting in the primary feathers of the wing and tail. It frequently supports merely downy barbs, as in the Gallinæ, and is occasionally reduced to a single barb, or is wanting altogether, as in the Owls, many Picariæ (Alcedo, Upupa), and Ducks, &c. From either side of the main and accessory plumes arise the Barbs which form the vane (*vexillum*) of the feather. They are small lancet-shaped lamellæ, varying in form, length, and thickness, in different Birds. In like manner, from either side of the barbs, proceed the Barbules (*radii*), which are much more numerous and complex in their structure than the barbs. Occasionally, like as in a tripinnate leaf, the barbules are provided again with smaller accessory barbules, constituting a third series. The barbules are

called, in accordance with their form and function, either *cilia* or *hamuli*. The former, where they occur, as in the feathers of the Goose, are the most numerous of all the parts of the feather, and proceed with the hooklets only from the foremost series of barbs; they are situated only upon the upper edge of the barb, and stand either in a double or only a single row. In the barbs of downy feathers small nodules appear to supply the place of the cilia. The cilia, like the hooklets, can only be seen with a magnifying power. The hooklets form likewise lateral processes of the barbs, but are found only upon their anterior series and upon the inferior side of each barb. They differ from the cilia by the hook-shaped curve of their extremities, the hooklets of an anterior series of barbs catching upon those of the one behind it, so that in this way the barbs are held fast. This arrangement is of importance for the flight of the bird, as by means of it the barbs of the feather are prevented from being torn asunder by the air, which would necessarily injure the power of flight.

The *Contour-feathers* are, as a rule, formed in the manner above stated, and have a perfectly-formed and stiff shaft. Their structure is most complete in the primaries of the wing, and the remigial feathers of the tail. The cilia and hooklets, however, are occasionally wanting, as in the Ostrich and Nandou (Rhea); and in other birds, as in the Cassowary, the barbs are absent. At the extremity of the bristles at the angle of the mouth, and upon the chin, and the eyelashes, the barbs are also wanting, or there is found only a membranous projection in place of a vane. The remarkably long spurs of the wing in the Indian Cassowary are shafts without any barbs.

The *Down-feathers* pass occasionally into quill-feathers; although they mostly lie concealed, yet they frequently form large freely exposed masses, as upon the neck of many of the Vultures. A down-feather frequently stands in the middle between four quill-feathers, and forms with them a quincunctial figure. The true down feathers exhibit an articulated structure, and appear like so many cones inserted in each other, and exhibit under the microscope, when they are of a gray color, a particolored appearance like that of the gray hairs of the Mouse, &c. The broader nodules are black, the intervals between them transparent and colorless. The down-feathers of nestling and young birds have very delicate barbs, and none, or only very small, nodose dilatations.

The *Plume-feathers* (filo-plumæ) differ very strikingly from the

two kinds already named, by a very slender stiff stem and a marrowless, transparent, very slender shaft, with very fine round barbs, not provided with ciliary, nor connected by hook-shaped, barbules. The barbs are occasionally entirely wanting and then these feathers resemble hairs. They occur in all birds, but are often easily overlooked; they are always associated with the quill-feathers, so that upon the head, neck, and trunk, one or two filamentary feathers stand quite near to each of the quill-feathers, and appear to proceed along with them from the same tegumentary capsule. It is more rare to find, as in the Herons and birds of the duck-kind, several, even so many as ten, filamentary feathers near to each quill-feather.

OSSEOUS SYSTEM.

The Skeleton of Birds presents a remarkable contrast to that of the other Vertebrata, while, at the same time, nearly all its forms throughout the class are characterized by a great uniformity.

One special peculiarity is met with in the internal structure of the bones, which are more or less hollow internally, devoid of marrow, and permeated by air. For the latter purpose many of them are provided with openings, which stand in relation to certain air-cells of the body (which will be described in treating of the respiratory organs), and are filled from them with air. As a general rule, the capacity and extent of these openings throughout the skeleton depends upon the size of the bird, and its powers of flight. Small, though very rapidly flying birds, have few hollow bones; in large and very high flying species, they are, on the other hand, most numerous. In many Birds, all or nearly all the bones are solid. In several of the bones, there is a predominant tendency over others to this hollow structure, as is found most frequently the case in the humerus, cranium, and sternum, but more rarely in the femur, and very rarely in the bones situated below the elbow and knee-joints. The bones are filled through one or many openings, which occupy different situations, according to the genera and species. Thus the small Passerine birds, many small Grallæ and Palmipedes, as the Snipes, Terns, Moor-hens, &c., have no bones for the reception of air, except some of the cranial, which are always filled with air from the nose. The most complete want of pneumatic permeability in the bones is at present to be observed in the Apteryx of New Zealand, a bird belonging to the order Brevipennes, and which is destitute also of air-cells. In some of the larger Passerine birds, as

the Crows, Shrikes, the humerus is the least hollow. The femur is far more generally filled with medullary tissue, but in the Diurnal birds of Prey it is permeated by air as well as the sternum, vertebræ, ribs, and pelvic bones. In the Owls, the femora of which contain marrow, the cranium is very much elevated by the large and wide air-cells of the diplöe. In the Pelicans very many of the bones receive air. The air openings are developed to the greatest extent, however, in the genus Buceros, where, in addition to the cranial and Maxillary bones, the cervical vertebræ, the pelvis, the caudal vertebræ (but not the sternum and ribs), and all the bones of the extremities, even to the phalanges and toes, are permeated with air. As regards their situation, the air-openings are frequently characteristic of different genera. Thus, *e. g.* in the Vulture and Falcon, the air opening in the femur is placed anteriorly and superiorly beneath its head, as is also the case in the Stork and Picariæ, but in the Ostrich, the Blackbird, and Thrush, it is situated posteriorly; in Buceros melanoleucos there are two pneumatic openings, one superiorly and in front of the femur, the second inferiorly and posteriorly. The Ostrich has the humerus permeable to the air; in the Cassowary, however, it is full of marrow, which is the case also in most of the Scansores, Gallinæ, Grallæ, and Palmipedes. In the Pelican, the Peacock, Bustard, this bone is again found permeable to air. In young birds those bones which at a later period admit air, are filled with marrow, which first of all becomes gradually absorbed. Those bones in the birds' skeleton which convey air differ at the first glance from the rest by their greater whiteness, and more compact cancellated structure; they contain also more earthy constituents.

The *Cranium* of Birds is peculiar in the early union of its separate bones and the complete obliteration of their connecting sutures, so that a complete bony case is formed, which encloses the brain and leaves free only the occipital foramen and the openings for the exit of the nerves. In very young birds, however, the several bones and their sutures may be distinguished. The *occipital* bone consists, as in most Amphibia, of four primary elements, the body, the two condyloid, and the superior occipital. The articulating condyle consists of a single round tubercle. The foramen magnum is sometimes perpendicular, as in the Gallinæ, Grallæ, and Palmipedes, *e. g.* the Goose, but more frequently horizontal, in which case the posterior part of the skull projects in a vaulted form behind it, as in the Rapaces and Passeres, the Woodpeckers, and many of the Grallatorial birds. In the Snipe especially it lies very

far forward and horizontal, so that the cranium is very much rounded. In the Rapaces, Passeres, and Scansores, as also in many of the Grallæ and Brevipennes, the cranium exhibits, particularly upon its back part, very smooth convexities, and is devoid of those singular muscular ridges which occasionally, as in the Gulls and Herons, form high ridges corresponding in situation with the direction of the lamboidal suture, and to which the muscles of the neck are attached. Young birds have a rounder form of skull than adults. There is found not unfrequently situated above the foramen magnum, and chiefly in the superior portion of the occipital bone, a considerable opening or fontanelle, filled up only by ligaments, *e. g.* in many Grallæ and Palmipedes, as the Goose, Duck, Crane, Snipe, Flamingo, Spoonbill, and Ibis, while this structure is often wanting in very closely-allied genera. In the Cormorant (Carbo), at least in the larger species of that genus, there is situated loosely upon the posterior surface of the occipital bone, to which it is attached merely by ligament, a long pyramidal and accessory bone, directed straight backward. In the *sphenoid* bone we distinguish a mostly narrow body (spine-shaped anteriorly) directed forward, as also the alæ majores, which confluent with it at an early period, are perforated by the openings for the fifth pair of nerves, and give off in the direction outward and downward a peculiar hook-shaped process, or postero-superior jugal process. This process is occasionally very strongly hook-shaped, as in Buceros. It coalesces occasionally, as in the Gallinæ, with an inferior process of the same name, coming from the temporal bone, so that an aperture is thus formed between them. In the Parrots it is developed to the greatest degree, and projects far forward, so that in many of the species it coalesces with the lacrymal bone, and forms an arch beneath the orbits; this occurs also in Scolopax rusticola. A peculiar pair of distinct and mostly narrow style-shaped bones converging together anteriorly, which articulate in front with the palate bones, behind with the ossa quadrata, and often, by means of a third joint in the middle, with the body of the sphenoid, may be regarded as the inferior wings of that bone. These inferior wings, called by other writers *ossa communicantia*, exhibit in other respects mauy diversities. They are short and thick in the Gallinæ, most frequently long and style-shaped, as in the Rapaces, and Passeres, and most of the Grallæ, Palmipedes, and Picariæ. In the Woodpeckers they support superiorly a free process. Their third broad articulation provided with a smooth cartilage occurs, *e. g.* in

the Owls, the Pigeons, Snipes, Goatsuckers, and birds of the Duck kind, and contributes to the movement of the superior maxillary arch. The *temporal* bone consists of a cranial portion which encloses the organ of hearing, and is formed by the early coalescence of the petrous, squamous, and mastoid portions; the squamous frequently gives off an inferior spine-shaped zygomatic process, not connected, however, with the jugal bone; the mastoid process is but slighty developed, and there is moreover an articular portion, the *tympanic* or *os quadratum*. This bone, which is free, and wanting in the Mammalia, occurs constantly in the other Vertebrata, where it often consists of several portions; it very generally projects superiorly into two processes, the posterior one of which, the largest, articulates by a rounded head with the cranium, while the anterior remains free. Inferiorly it articulates with the lower jaw, inferiorly and externally with the jugal bone, inferiorly and posteriorly with the lower wings of the sphenoid. Laterally, and in the direction inward, the os quadratum gives off a peculiar tympanic process, which helps to form the posterior wall of the tympanic cavity, and partakes in the movement of the upper jaw. This process exhibits no inconsiderable differences in the several orders. The *parietal* bone, originally consisting of two halves, abuts anteriorly against the frontal, which is also double in early life. The latter has often concave depressions or deep grooves, as in the Gulls and many other Aquatic birds, for the reception of the nasal glands, which here lie upon the edge of the orbital cavity. The *ethmoid* is occasionally present only as a single perpendicular plate, which, with the sphenoid, forms either the closed or more or less perforated partition of the orbits. This partition is frequently, in nearly allied birds, completely bony, as in the Stork, or very perforated and membranous, as in the Heron. The ethmoid, however, frequently exhibits traces of lateral portions, as in the Passeres, *e. g.* Corvus, the Rapaces, and many Scansores, where they are more strongly developed, and abut against the lacrymal bone.

As regards the *Facial bones*, an *intermaxillary* bone of mostly large size and single (rarely, as in the Gallinæ and Snipes, of small or minute size), forms the principal part of the upper bill, and exhibits great diversities of form. Superiorly and posteriorly it is slit for the reception of the nasal cavities, and sends usually a long, narrow, flattened process between the nasal bones. In the Parrots the intermaxillary bone is merely united by ligament to the skull, and is therefore very moveable, while in other cases the union is

usually effected by means of a bony suture. The *superior maxillaries*, which are generally small, and removed quite to the sides of the upper mandible, are united posteriorly by a slender flattened jugal process to the bone of that name, so as to form a jugal arch. The *nasal* bones are flat and mostly of considerable size, lie in front of the frontals, and give off frequently two processes directed forward, as in the Gallinæ, where they are very deeply excavated so as to present the form of an arch. By means of this excavation in the bones, the nasal foramina coalesce posteriorly. Near to and externally to the nasal and frontal bones, upon the anterior edge of the orbital cavity, are situated the *lacrymal* bones, for the most part separate, and exhibiting great varieties in their degree of development, but which are, as a rule, however, very large, and project inferiorly into a hook-shaped process. In the Woodpeckers and Parrots they are very firmly blended with the skull; they are very small in the Gallinæ, while, on the contrary, in the Spoon-bill, Albatross, and other birds, they abut against the jugal arch, and are united to it by a ligament which is frequently ossified. In the Parrots and Snipes the lacrymal bone forms a ring around the orbit after it has united with the jugal process of the sphenoid bone. The lacrymal bone is very much developed in the Diurnal birds of Prey, where it helps to form the roof of the orbit, and supports externally the os superciliare, which occurs even in the Ostriches. The *palatal* bones exhibit important diversities. They are in general two elongated slender bones, which are moveably united, partly together, and partly with the sphenoid (rarely by means of a suture), but are firmly anchylosed in front with the superior maxillary bones. They are flat, broad, and horizontal, in the Birds of Prey; particularly broad in Caprimulgus; narrow and not united in the Passeres, with but few exceptions, such as Loxia coccothraustes, where they are placed vertically, as in the Parrots; they are very narrow, especially in front, in the Gallinæ; wedge-shaped and hollowed out into the form of a groove in many Grallæ and Palmipedes, as the Storks and Herons, and anchylosed so as to form a short tube along with the vomer in Buceros; in the Goose they are perpendicular, and so also in the Parrots, where however they consist of much broader laminæ, with a strong free process given off posteriorly and inferiorly; in the Brevipennes they are anchylosed by suture with the Sphenoid. Between them lies the *vomer*, which is wanting in the Parrots and Gallinæ, but which is most strongly developed in the Palmipedes, and is generally represented by a

perpendicular bony plate. The *jugal* bone, which is throughout the class very long, slender, and flattened, consists of two pieces, and is united posteriorly to the os quadratum by fibro-cartilage, anteriorly with the jugal process of the superior maxillary by suture, forming nearly always a straight bridge of bone parallel with the lower jaw. It is only in the Goatsucker (Caprimulgus) that the jugal bone is arched in the direction outward to conform with the similarly projecting posterior piece of the lower jaw. In other instances the zygomatic arch is very short and strong, as in Buceros, or very slender, as in the Snipes.

The *Lower Jaw* consists of a single anterior and five pairs of posterior pieces, perfectly analogous to those in the lower jaw of the Amphibia. They soon, however, coalesce, the anterior pretty firmly, the posterior pieces completely. Instead of the articulating condyle, there is found, as in all the Vertebrata below the Mammalia, an articulating cavity for the reception of the os quadratum, and which gives off internally and superiorly a kind of coronoid process, and in the direction backward a frequently long and very much developed process, as is seen particularly in the Gallinæ, *e. g.* the Grouse. Minor differences also frequently occur; thus in Cypselus the lower jaw is in the form of a very narrow and slender arch, while in the Parrots it is formed of deep perpendicular bony walls; in both the processes are wanting. In the Crow and most Passeres the posterior half of the lower jaw is perforated by a large opening. It is remarkable that in birds the whole apparatus of the superior maxilla (supporting the upper Mandible) admits generally of a slight, occasionally even a considerable degree of motion, in the direction upward and forward, which is effected by the moveable connexion posteriorly of the palatal, sphenoid, jugal, and quadratal bones.

The different portions of the *Vertebral Column* in birds exhibit several peculiar and remarkable arrangements. The number of the vertebræ not only varies very considerably in the orders, but also among the genera and species, and even in individuals of the same species; the Swan, for example, has generally 23, but frequently also 24, cervical vertebræ. The relative numbers of the vertebræ are, however, in general more constant than in the Amphibia. The cervical vertebræ are always more numerous than in the Mammalia; as a rule, there are from 11—12 (rarely only 9 or 10), as in most Rapaces, Passeres, and Scansores birds; 13—15 in the Gallinæ, 16—19 in the long-necked Grallæ and Palmipedes, as in the Stork, Crane, Heron, and also in the Ostrich and Cassowary; 23—24, as in

the Swan, being the highest number. The atlas is depressed and ring-shaped, and generally articulates by its capsular surface with the single condyle of the occipital bone, so that the head can be freely rotated in a circle upon this joint, and directed completely backward. In the Ostrich and Penguin a pair of smaller lateral articulating surfaces are met with, which are directly confluent with the central articulating cavity of the atlas, and receive two corresponding divisions of the tubercle of the occiput, formed by the lateral portions of that bone. The second cervical vertebra is deeper, and has a processus dentatus; its body is united to the atlas by a single synovial capsule; an annular and a straight check ligament are met with binding the processus dentatus to the atlas and tubercle of the occipital bone. In Buceros the two superior cervical vertebræ are blendid together and united into one. The rest of the cervical vertebræ have oblique, transverse, and slightly-developed spinous processes, namely, upon the middle part of the neck, and the most posterior have also occasionally inferior spinous processes. The transverse processes are very thick and strong, and have a double root, so that they form a ring, and in the entire skeleton an interrupted canal, within which the vertebral vessels and the cervical portion of the sympathetic nerve are lodged. The bodies of these vertebræ are very moveable upon each other, concave on their superior surface, convex posteriorly, and are united by free capsular ligaments, with only very thin intervening cartilages. The superior can be moved usually more freely in the direction forward, the middle more backward, and the inferior again forward, whence is produced the peculiar sigmoid curve of the neck which is visible in the skeletons of most Birds. The spinal canal is of various form and width in the several divisions of the cervical vertebræ, a condition which, in long-necked Birds, has especial reference to the great degree of mobility in the neck; the roots of the spinous processes are also united, for greater security during the numerous movements of the vertebræ, by elastic ligaments, an arrangement which, along with the preceding one, is plainly for the purpose of protecting the spinal cord during the extensive inflections of the neck. The number of dorsal vertebræ is in general less, and subject to fewer varieties; there are mostly found from 7—9, rarely 10, as in the Ostrich, Cassowary, Goose, and still more rarely 11, as in the Swan and some Ducks. They are but slightly moveable, and are often, especially the hindermost, completely anchylosed together and to the sacrum. This normal state of anchylosis, like that of the sacral vertebræ, was

here necessary, from the posterior extremities being brought behind the centre of gravity of the body. With this view the superior spinous processes are not unfrequently blended together so as to form a continuous ridge, and in the Flamingo, even the second to the fifth dorsal vertebræ are completely fused together, and their transverse and spinous processes have coalesced into a single plate of bone. The bodies relatively to those of the cervical vertebræ are short, and more or less strongly compressed laterally, in the Penguins being quite crest-shaped, while on the contrary they are very broad in the Ostrich. The anterior usually support strong elongated, and, as in Eudytes and other birds, disjoined inferior spinous processes for the attachment of the recti antici majores muscles. The lumbar vertebræ are anchylosed with the sacrum and pelvis to form a single lumbo-sacral bone. The portions however which belong to the several bodies can be more or less clearly distinguished. The lumbo-sacral bone is mostly composed of from 9 to 10, or even more, as 15 vertebræ (many Grallatorial and several Gallinaceous birds), rarely of 17 (as in the Ostrich), or 19 (Cassowary). The caudal series of vertebræ exhibits slight differences; the vertebræ are here very moveable and few in number, and have for the most part considerable transverse and superior, as frequently also inferior spinous, processes. They are hollow even to the last, and form the canal for the spinal marrow. The last caudal vertebra is always of a peculiar shape, and has mostly a strong share-shaped spinous process arising from it, upon which the remigial feathers of the tail are supported. This process is absent however in birds which have a rudimentary tail, as the Struthionidæ and Penguins; on the contrary, in some of the Scansorial birds where the tail serves as an instrument of support in the act of climbing, as in the Woodpeckers and Tree-creepers, the body of the last caudal vertebra is very broad, and supports a peculiar flattened and concave plate.

The number of the *Ribs* varies in accordance with that of the dorsal vertebræ. They always articulate by means of a small head with the body of a single vertebra near to its anterior border, and with the corresponding transverse process by their tubercle. Anteriorly there are situated mostly two, rarely, as in the Cassowary, four false ribs, generally small, and running to a point, which do not reach the sternum. The succeeding true ribs are always laterally compressed and very flat, with the exception of the last rib and the one before it; from about their middle there proceeds a strong and elongated process, which is very seldom moveably united to the rib, as in the